Remarks:

Claims 1-10 are pending in this application. The examiner rejected claims 1-10 under 35 U.S.C. § 103(a) as obvious over U.S. Pat. No. 5,062,844 to Jamison *et al.* ("Jamison et al."). According to the examiner, "Jamison et al. disclose each and every structural element of the frame set forth in claims 1-10, a radiolucent body material, as set forth in column 2, lines 45-57, column 3, lines 1-21, a stiffening member (45) in bed in a substantially radiolucent body material, as set forth in column 4, lines 5-27, the frame being annular, arcuate, light weight, and inert with respect to human body or household substances, comprises a polycarbonate compound, autoclave and adapted for attachment of a variety of wire and pin securing device and a second stiffening member (46) embedded in the radiolucent body material; as set forth in column 5, lines 10-62; column 6: 16-50; and as best seen in FIGS. 1-11." Office Action at 2. The examiner notes "that Jamison et al. did not teach of 'beryllium' ", but states that "Jamison et al. did teach of a stiffening member that is made of carbon fiber, which is radiolucent, just like the 'beryllium' claimed by the applicant. Therefore, using 'beryllium' or 'carbon fiber' would have been an obvious matter of using a preferred material, it has held to be within the general skill of a worker in the art to select a known material on the basis of its suitability for the intended use as a matter of obvious design choice." *Id.* at 3. Applicant respectfully requests reconsideration of claims 1-10 for the reasons set forth below.

The examiner fails to appreciate that Jamison et al. teaches away from the invention disclosed and claimed in the presently pending application. Both the pending application and Jamison et al. recognize a need for light-weight yet rigid fixation frames and that the metal rings of the prior Ilizarov fixation system are heavy and radiopaque. Jamison et al., for example, explains that "[t]he metallic nature of the Ilizarov system has presented clinical difficulties in the

evaluation of patient's radiographs, because of the high radiopacity of the metallic parts. One of the most common problems incurred is that the surveillance of bone healing or bone distraction is impeded by radiographic shadowing resulting from the metallic components used in the Ilizarov system. Secondarily, the fully assembled Ilizarov frame can constitute a significant added weight which can be problematic in pediatric and upper extremity cases." Col. 2, lines 26-36.

In an attempt to resolve those difficulties, Jamison et al. teaches away from the metallic Ilizarov frame material toward non-metal frame material. Indeed, the device of Jamison et al. is merely one device in a long history of attempted improvements on admittedly inadequate non-metallic frames. Jamison et al. recounts a number of non-metallic prior art frames:

1. "Fixano manufactured a device sold by Danek in the U.S. which used carbon fiber reinforced plastic half rings." Col. 2, lines 3-5.
2. "U.S. Pat. No. 3,977,397 discloses a liner impregnated phenolic ring of circular cross section." Col. 2, lines 6-7.
3. "Other patents relating to the Ilizarov system include the Koeneman et al. patents, U.S. Pat. Nos. 4,757,809 and 4,747,400. In the '400 Pat., the frame has side rails, each with a polyamide foam core, wrapped with a composite of graphite or glass fibers impregnated with thermo-plastic or thermo-setting resin." Col. 2, lines 8-14.
4. "European patent EP 87112273 and U.S. Pat. No. 4,604,996 issued to W. Herzberg discuss the use of glass fibre reinforced hoses and connections which can be filled with self-curing plastics, wherein such external fixture can be produced at low cost and offers no obstruction to x-rays." Col. 2, lines 14-19.
5. "The Mears patent, U.S. Pat. No. 4,620,533, relates to an apparatus for externally fixing bone fractures with clamps having universal ball joints to pins and a rigid bar. The bar is preferably of epoxy/carbon or epoxy/fiberglass composite, and the clamps are of nylon/carbon fiber composite, both being x-ray translucent." Col. 2, lines 20-25.

Notably, Jamison et al. recognizes the problems with those devices: "Prior attempts to solve this problem have not been able to supply the desirable physical and load carrying characteristics of

the present invention including light weight, high strength, high modulus of elasticity (i.e., near that of steel) and radiolucency." Col. 2, lines 37-41. Clearly, Jamison et al.'s criticism of the prior art is evidence not only of a long-felt but unsatisfied need for lightweight, stiff, radiolucent fixator frames, but of substantial and relatively unsuccessful attempts by those skilled in the art to fill that need. Rather than return to using metallic frame material, however, Jamison et al. simply reconfigures the conventional frame materials used in the prior art. In that regard, Jamison et al. – along with the prior art criticized by Jamison et al. – teach away from using beryllium as a stiffening member. As is made clear below, the device of Jamison et al. is yet another relatively unsuccessful attempt to meet that need.

In particular, Jamison et al. disclose a ring of "plastic-carbon composite material," col. 2, lines 64-65, that Jamison et al. try to configure in a way that the "flexural rigidity" will "at least approach[ ] the flexural rigidity of steel rings of the same diameter." Col. 4, lines 12-13. According to Jamison et al., "composite rings have a modulus of elasticity typically only 30% that of steel," and "the simplest way to achieve equal flexural rigidities is to increase the width and the thickness of the cross section of a composite ring which is equal in diameter to the steel ring," *i.e.*, make the ring more bulky. Col. 3, lines 45-52. And the weight of such a ring, Jamison et al. note, is comparable to that of a steel ring. Col. 3, lines 38-41. That is, Jamison et al.'s device does not meet the need for light weight and non-bulky fixator frames, and thus provide an incomplete solution.

The invention of the present application, on the other hand, returns to using a metal in the fixator frame, namely, beryllium. According to the U.S. Geological Survey, "[b]eryllium (Be) is one of the lightest of all metals and has one of the highest melting points of any light metal. Beryllium metal is used principally in aerospace and defense applications because of its

stiffness, light weight, and dimensional stability over a wide temperature range." *See* Estrada Declaration, Exh. A. The Los Alamos National Laboratory further explains that beryllium has a modulus of elasticity "about one third greater than that of steel" and "has a high permeability to X-rays." *See* Estrada Declaration, Exh. B (emphasis added). *See also* Estrada Decl., Exh. C (Wikipedia.com entry for "beryllium" under "Notable Characteristics:" "The modulus of elasticity of beryllium is approximately ⅓ greater than that of steel."). Specifically, the modulus of elasticity of beryllium is 287 GPa (~42 million psi[1]), *see* Estrada Decl., Exh. C, compared to steel's modulus of elasticity at 28 million psi. *See* Jamison et al, col. 3, lines 57-58. Providing beryllium as a stiffening member as claimed in the present application, therefore, permits a frame that is radiolucent, lightweight *and* substantially less bulky – and thus meets the need confessed but unmet by Jamison et al.

In view of the foregoing, Applicant again respectfully urges that examiner has not made a prima facie case of obviousness: the examiner has failed to "determine[ ] ' "the scope and content of the prior art," ' ascertain[ ] ' "the differences between the prior art and the claims at issue," ' and resolve[ ] ' "the level of ordinary skill in the pertinent art." ' " *In re Kahn*, 441 F.3d 977, 985 (Fed. Cir. 2006). The examiner asserts that Jamison et al. could be modified to arrive at the claimed invention without considering the stated background against which Jamison et al. developed, and thus failed to consider the differences between that prior art and the claimed invention, such as the differences discussed above between carbon fiber and beryllium. Rather, the examiner has relied on a single point of similarity, namely, radiolucence, to assert obviousness – which, when the foregoing is considered, is a superficial comparison.

[1] Unit conversion may be obtained by typing "convert 287 gigapascals to psi" into the www.Google.com search engine.

Moreover, the examiner fails to devote any analysis to the level of ordinary skill in the art. The examiner concedes that Jamison et al. does not teach use of beryllium at all, and the examiner has pointed to no motivation in Jamison et al. to use beryllium as a stiffening member. *See Kahn*, 441 F.3d at 986 ("[T]o establish a prima facie case of obviousness based on a combination of elements disclosed in the prior art, the Board must articulate the basis on which it concludes that it would have been obvious to make the claimed invention. * * * * By requiring the Board to explain the motivation, suggestion, or teaching as part of its prima facie case, the law guards against hindsight in all cases—whether or not the applicant offers evidence on secondary considerations * * *."). Given that Jamison et al. is the only asserted reference, it is clear that the examiner concludes beryllium to be part of the background knowledge of one of ordinary skill in the art. But the examiner fails to provide the support or rationale for that conclusion required to establish obviousness. *See Alza Corp. v. Mylan Labs., Inc.*, ___ F.3d ___, ___, slip op. at 5-6 (Fed. Cir. 2006) ("At its core, our anti-hindsight jurisprudence is a test that rests on the unremarkable premise that legal determinations of obviousness, as with such determination is, generally, should be based on evidence rather than on mere speculation or conjecture."). That lack invites the conclusion that the examiner has simply used hindsight in asserting obviousness. *See Kahn*, 441 F.3d at 986 ("When the Board does not explain the motivation, or the suggestion or teaching, that would have led the skilled artisan at the time of the invention to the claimed combination as a whole, we infer that the Board used hindsight to conclude that the invention was obvious."). That is error, and the applicant respectfully requests that the examiner withdraw the obviousness rejection.

The foregoing discussion of the prior art and beryllium rebuts the examiner's position that there is a motivation to modify Jamison et al. to use beryllium in place of carbon fiber. *See*

Office Action at 3. According to the examiner, the only difference between applicant's stiffening member and Jamison et al.'s stiffening member is that applicant's stiffening member is made of 'Beryllium' and Jamison et al.'s stiffening member is made of 'carbon Fiber.' However, both 'beryllium and carbon fiber' are radiolucent, which is being claimed by applicant." *Id.* Deeming carbon fiber to be an obvious alternative to beryllium on the basis that both are radiolucent is akin to deeming a pineapple to be an obvious alternative to a grape on the basis that both are fruit. It is true that both carbon fiber and beryllium are radiolucent, but their properties are quite dissimilar. As noted above, beryllium is a metal and carbon fiber is not. Furthermore, beryllium is toxic and "potentially carcinogenic," *see* Estrada Decl., Exh. C (Wikipedia.com entry for "beryllium" under "Health Effects: Precautions"), thus further weighing against the asserted motivation to combine.

In view of the foregoing, the applicant respectfully submits the claims 1-10 are in condition for allowance, and such is earnestly requested. If the examiner believes that a telephone conference would advance the prosecution of this application, the examiner is respectfully requested to contact the undersigned attorney. The Commissioner is authorized to charge any required fees for this submission or credit any overpayment to Deposit Account No. 03-3483.

Respectfully submitted,

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ATTORNEYS FOR APPLICANT

Date: September 29, 2006

DECLARATION OF HECTOR MARK ESTRADA, JR. UNDER 37 § C.F.R. 1.132

I, Hector Mark Estrada, Jr., declare under penalty of perjury that:

1. Attached as Exhibit A is a true and correct copy of a web page from the web site of the U.S. Geological survey.
2. Attached as Exhibit B is a true and correct copy of a web page from the web site of the Los Alamos National Laboratory.
3. Attached as Exhibit C is a true and correct copy of a web page from the Wikipedia.com web site.

I declare under penalty of perjury under the laws of the United States of America the foregoing is true and correct.

Executed: September 29, 2006.

H. Mark Estrada Jr.

Hector Mark Estrada, Jr.

Exhibit A

Beryllium
Statistics and Information

Publications	Contacts	Subscribe

Beryllium (Be) is one of the lightest of all metals and has one of the highest melting points of any light metal. Beryllium metal is used principally in aerospace and defense applications because of its stiffness, light weight, and dimensional stability over a wide temperature range. Beryllium-copper alloys are used in a wide variety of applications because of their electrical and thermal conductivity, high strength and hardness, good corrosion and fatigue resistance, and nonmagnetic properties. Beryllium oxide is an excellent heat conductor, with high strength and hardness, and acts as an electrical insulator in some applications. The United States, one of only three countries that process beryllium ores and concentrates into beryllium products, supplies most of the rest of the world with these products.

Publications

If you are interested in receiving an email notice when a publication is added to this page, please refer to Minerals Information List Services.

(To view or print a document in PDF format, download the free Adobe Acrobat Reader.)

Annual Publications

Mineral Commodity Summaries

- Beryllium
  PDF Format:
  | 1996 | 1997 | 1998 | 1999 | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 |
- Appendixes

Minerals Yearbook

- Beryllium
  PDF Format:
  | 1994 | 1995 | 1996 | 1997 | 1998 | 1999 | 2000 | 2001 | 2002 | 2003 | 2004 |
  XLS Format:
  | 2002 | 2003 | 2004 |
- Archive

| 1932-1993 |
- Recycling-Metals

Special Publications

- Beryllium Recycling in the United States in 2000
  C-1196-P
- Historical Statistics for Mineral and Material Commodities in the United States
  Data Series 140
  - Beryllium
- Metal Prices in the United States through 1998
  - Beryllium (PDF)

Contacts

- **USGS Commodity Specialist**
  Kim B. Shedd (acting)
  Phone: 703-648-4974
  Fax: 703-648-7757
  Email: kshedd@usgs.gov

- USGS Resource Specialist

Exhibit B

Atomic Number:	4	**Atomic Radius:**	113.3 pm
Atomic Symbol:	Be	**Melting Point:**	1287 ?C
Atomic Weight:	9.01218	**Boiling Point:**	2471 ?C
Electron Configuration:	$[He]2s^2$	**Oxidation States:**	2

History

(Gr. *beryllos*: beryl; also called Glucinium or Glucinum, Gr. *glykys*: sweet) Discovered in the oxide form by Vauquelin in both beryl and emeralds in 1798. The metal was isolated in 1828 by Wohler and by Bussy independently by the action of potassium on beryllium chloride.

Sources

Beryllium is found in some 30 mineral species, the most important of which are bertrandite, beryl, chrysoberyl, and phenacite. Aquamarine and emerald are precious forms of beryl. Beryl and bertrandite are the most important commercial sources of the element and its compounds. Most of the metal is now prepared by reducing beryllium fluoride with magnesium metal. Beryllium metal did not become readily available to industry until 1957.

Properties

The metal, steel gray in color, has many desirable properties. As one of the lightest of all metals, it has one of the highest melting points of the light metals. Its modulus of elasticity is about one third greater than that of steel. It resists attack by concentrated nitric acid, has excellent thermal conductivity, and is nonmagnetic. It has a high permeability to X-rays and when bombarded by alpha particles, as from radium or polonium, neutrons are produced in the amount of about 30 neutrons/million alpha particles.

At ordinary temperatures, beryllium resists oxidation in air, although its ability to scratch glass is probably due to the formation of a thin layer of the oxide.

Uses

Beryllium is used as an alloying agent in producing beryllium copper, which is extensively used for springs, electrical contacts, spot-welding electrodes, and non-sparking tools. It is applied as a structural material for high-speed aircraft, missiles, spacecraft, and communication satellites. Other uses include windshield frame, brake discs, support beams, and other structural components of the space shuttle.

Because beryllium is relatively transparent to X-rays, ultra-thin Be-foil is finding use in X-ray lithography for reproduction of micro-miniature integrated circuits.

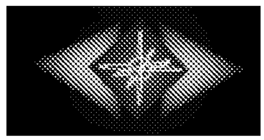
Beryllium is used in nuclear reactors as a reflector or moderator for it has a low thermal neutron absorption cross section.

It is used in gyroscopes, computer parts, and instruments where lightness, stiffness, and dimensional stability are required. The oxide has a very high melting point and is also used in nuclear work and ceramic applications.

Handling

Beryllium and its salts are toxic and should be handled with the greatest of care. Beryllium and its compounds should not be tasted to verify the sweetish nature of beryllium (as did early experimenters). The metal, its alloys, and its salts can be handled if certain work codes are observed, but no attempt should be made to work with beryllium before becoming familiar with proper safeguards.

Title Picture: beryl orb



Sources: CRC Handbook of Chemistry and Physics and the American Chemical Society.

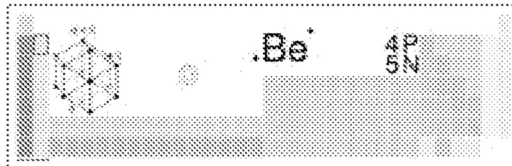
Last Updated: 12/15/2003,? Chemistry Operations

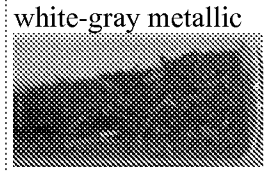
Exhibit C

Beryllium

From Wikipedia, the free encyclopedia

Beryllium is the chemical element in the periodic table that has the symbol **Be** and atomic number 4. A bivalent element, beryllium is a steel grey, strong, light-weight yet brittle, alkaline earth metal, that is primarily used as a hardening agent in alloys (most notably beryllium copper).

4	lithium ← beryllium → boron
- ↑ **Be** ↓ Mg	 periodic table - Extended Periodic Table

General	
Name, Symbol, Number	beryllium, Be, 4
Chemical series	alkaline earth metals
Group, Period, Block	2, 2, s
Appearance	white-gray metallic 
Atomic mass	9.012182(3) g/mol
Electron configuration	$1s^2\ 2s^2$
Electrons per shell	2, 2
Physical properties	
Phase	solid
Density (near r.t.)	1.85 $g \cdot cm^{-3}$
Liquid density at m.p.	1.690 $g \cdot cm^{-3}$
Melting point	1560 K (1287 °C, 2349 °F)
Boiling point	2742 K (2469 °C, 4476 °F)
Heat of fusion	7.895 $kJ \cdot mol^{-1}$
Heat of vaporization	297 $kJ \cdot mol^{-1}$
Heat capacity	(25 °C) 16.443 $J \cdot mol^{-1} \cdot K^{-1}$

Vapor pressure

P/Pa	1	10	100	1 k	10 k	100 k
at *T*/K	1462	1608	1791	2023	2327	2742

Atomic properties	
Crystal structure	hexagonal
Oxidation states	2 (amphoteric oxide)
Electronegativity	1.57 (Pauling scale)
Ionization energies (more)	1st: 899.5 $kJ \cdot mol^{-1}$
	2nd: 1757.1 $kJ \cdot mol^{-1}$

Contents

Notable characteristics

Beryllium has one of the highest melting points of the light metals. The modulus of elasticity of beryllium is approximately ⅓ greater than that of steel. It has excellent thermal conductivity, is nonmagnetic and resists attack by concentrated nitric acid. It is highly permeable to X-rays, and neutrons are liberated when it is hit by alpha particles, as from radium or polonium (about 30 neutrons/million alpha particles). At standard temperature and pressures beryllium resists oxidation when exposed to air (although its ability to scratch glass is probably due to the formation of a thin layer of the oxide). The speed of sound in beryllium (12,500m/s) is greater than in any other element.

History

The name beryllium comes from the Greek *beryllos*, beryl, from Prakrit *veruliya*, from Pāli *veuriya*; possibly from or simply akin to a Dravidian source represented by Tamil *veiruor*, *viar*, "to whiten, become pale."[1] At one time beryllium was referred to as **glucinium** (from Greek *glykys*, sweet), due to the sweet taste of its salts. This element was discovered by Louis Vauquelin in 1798 as the oxide in beryl and in emeralds. Friedrich Wöhler and A. A. Bussy independently isolated the metal in 1828 by reacting potassium and

beryllium chloride.

Occurrence

Beryllium is an essential constituent of about 100 out of about 4000 known minerals, the most important of which are bertrandite ($Be_4Si_2O_7(OH)_2$), beryl ($Al_2Be_3Si_6O_{18}$), chrysoberyl (Al_2BeO_4), and phenakite (Be_2SiO_4). Precious forms of beryl are aquamarine and emerald.

The most important commercial sources of beryllium and its compounds are beryl and bertrandite. Beryllium metal did not become readily available until 1957. Currently, most production of this metal is accomplished by reducing beryllium fluoride with magnesium metal. The price on the US market for vacuum-cast beryllium ingots was 338 US$ per pound ($745/kg) in 2001.[2]

$$BeF_2 + Mg \rightarrow MgF_2 + Be$$

See also beryllium minerals.

	3rd: 14848.7 $kJ \cdot mol^{-1}$
Atomic radius	105 pm
Atomic radius (calc.)	112 pm
Covalent radius	90 pm
Miscellaneous	
Magnetic ordering	diamagnetic
Electrical resistivity	(20 °C) 35.6 $n\Omega \cdot m$
Thermal conductivity	(300 K) 200 $W \cdot m^{-1} \cdot K^{-1}$
Thermal expansion	(25 °C) 11.3 $\mu m \cdot m^{-1} \cdot K^{-1}$
Speed of sound (thin rod)	(r.t.) 12870 $m \cdot s^{-1}$
Young's modulus	287 GPa
Shear modulus	132 GPa
Bulk modulus	130 GPa
Poisson ratio	0.032
Mohs hardness	5.5
Vickers hardness	1670 MPa
Brinell hardness	600 MPa
CAS registry number	7440-41-7
Selected isotopes	

Main article: Isotopes of beryllium

iso	NA	half-life	DM	DE (MeV)	DP
^7Be	syn	53.12 d	ε	-	^7Li
			γ	0.477	-
^9Be	100%	Be is stable with 5 neutrons			
^{10}Be	trace	1.51×10^6 y	β^-	0.556	^{10}B

References

Applications

- Beryllium is used as an alloying agent in the production of beryllium-copper because of its ability to absorb large amounts of heat. Beryllium-copper alloys are used in a wide variety of applications because of their electrical and thermal conductivity, high strength and hardness, nonmagnetic properties, along with good corrosion and fatigue resistance. These applications include the making of spot-welding electrodes, springs, non-sparking tools and electrical contacts.
- Due to their stiffness, light weight, and dimensional stability over a wide temperature range, beryllium-copper alloys are also used in the defense and aerospace industries as light-weight structural materials in high-speed aircraft, missiles, space vehicles and communication satellites.
- Thin sheets of beryllium foil are used with X-ray detection diagnostics to filter out visible light and allow only X-rays to be detected.
- In the field of X-ray lithography beryllium is used for the reproduction of microscopic integrated circuits.
- In the telecommunications industry, Beryllium is made into tools that are used to tune the highly magnetic klystrons used for high power microwave transmissions for safety.
- Because it has a low thermal neutron absorption cross section, the nuclear power industry uses this metal in nuclear reactors as a neutron reflector and moderator.
- Beryllium is used in nuclear weapons for similar reasons. For example, the critical mass of a plutonium sphere is significantly reduced if the plutonium is surrounded by a beryllium shell.
- Beryllium is sometimes used in neutron sources, in which the beryllium is mixed with an alpha emitter such as ^{210}Po, ^{226}Ra, ^{239}Pu or ^{241}Am.
- Beryllium is also used in the making of gyroscopes, various computer equipment, watch springs and instruments where light-weight, rigidity and dimensional stability are needed.
- Beryllium oxide is useful for many applications that require an excellent heat conductor, with high strength and hardness, with a very high melting point, and that acts as an electrical insulator.
- Beryllium compounds were once used in fluorescent lighting tubes, but this use was discontinued because of berylliosis in the workers manufacturing the tubes (see below).
- The James Webb Space Telescope[3] will have 18 hexagonal beryllium sections for its mirrors. Because JWST will face a temperature of −240 degrees Celsius (30 kelvins), the mirror is made of beryllium, a material capable of

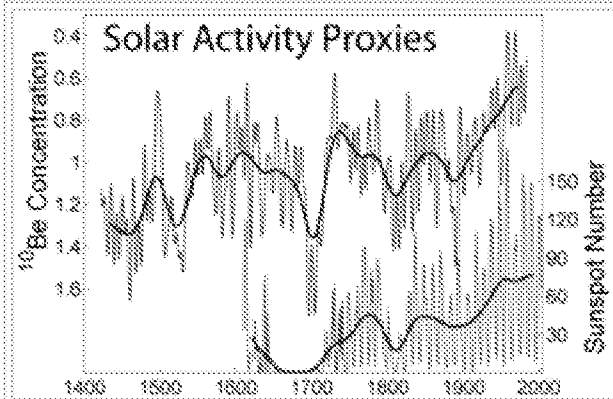
handling extreme cold better than glass. Beryllium contracts and deforms less than glass — and thus remains more uniform — in such temperatures.

- Beryllium is also used in the Joint European Torus fusion research facility, to condition the plasma facing components. [4]
- Beryllium has also been used in tweeter construction by the company Focal-JMlab on its flagship Utopia Be series as an alternative to titanium and aluminium, largely due to its lower density and greater rigidity.[5]

See also Beryllium compounds.

Isotopes

Of beryllium's 10 isotopes, only ^{9}Be is stable. Cosmogenic ^{10}Be is produced in the atmosphere by cosmic ray spallation of oxygen and nitrogen. Because beryllium tends to exist in solution at pH levels less than about 5.5 (and most rainwater has a pH less than 5), it will enter into solution and be transported to the Earth's surface via rainwater. As the precipitation quickly becomes more alkaline, beryllium drops out of solution. Cosmogenic ^{10}Be thereby accumulates at the soil surface, where its relatively long half-life (1.51 million years) permits a long residence time before decaying to ^{10}B. ^{10}Be and its daughter products have been used to examine soil erosion, soil formation from regolith, the development of lateritic soils, as well as variations in solar activity and the age of ice cores.



Plot showing variations in solar activity, including variation in ^{10}Be concentration.

The fact that ^{7}Be and ^{8}Be are unstable has profound cosmological consequences as it means that elements heavier than beryllium could not be produced by nuclear fusion in the Big Bang. Moreover, the nuclear energy levels of ^{8}Be are such that carbon can be produced within stars, thus making life possible. (See triple-alpha process and Big Bang nucleosynthesis).

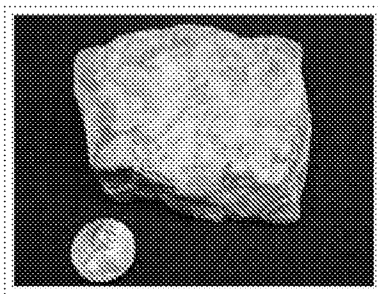
The shortest-lived known isotope of beryllium is ^{13}Be which decays through neutron emission. It has a half-life of 2.7×10^{-21} seconds. ^{6}Be also is also very short-lived with a half-life of 5.0×10^{-21} seconds.

The exotics ^{11}Be and ^{14}Be are known to exhibit a nuclear halo.

Health effects

Precautions

Beryllium and its salts are toxic substances and potentially carcinogenic. Chronic berylliosis is a pulmonary and systemic granulomatous disease caused by exposure to beryllium. Acute beryllium disease in the form of chemical pneumonitis was first reported in Europe in 1933 and in the United States in 1943. Cases of chronic berylliosis were first described in 1946 among workers in plants manufacturing fluorescent lamps in Massachusetts. Chronic berylliosis resembles sarcoidosis in many respects, and the differential diagnosis is often difficult.


Beryllium ore

Although the use of beryllium compounds in fluorescent lighting tubes was discontinued in 1949, potential for exposure to beryllium exists in the nuclear and aerospace industries and in the refining of beryllium metal and melting of beryllium-containing alloys, the manufacturing of electronic devices, and the handling of other beryllium-containing material.

Early researchers tasted beryllium and its various compounds for sweetness in order to verify its presence. Modern diagnostic equipment no longer necessitates this highly risky procedure and no attempt should be made to ingest this substance.

Beryllium and its compounds should be handled with great care and special precautions must be taken when carrying out any activity which could result in the release of beryllium dust (lung cancer is a possible result of prolonged exposure to beryllium laden dust).

This substance can be handled safely if certain procedures are followed. No attempt should be made to work with beryllium before familiarization with correct handling procedures.

A successful test for beryllium on different surface areas has been recently developed. The procedure uses fluorescence when beryllium is bound to sulfonated hydroxybenzoquinoline to detect up to 10 times lower than the recommended limit for beryllium concentration in the work place. Fluorescence increases with increasing beryllium concentration. The new procedure has been successfully tested on a variety of surfaces.

Inhalation

Beryllium can be harmful if inhaled and the effects depend on period of exposure. If beryllium air levels are high enough (greater than 100 $\mu g/m^3$), an acute condition can result, called acute beryllium disease, which resembles pneumonia. Occupational and community air standards are effective in preventing most acute lung damage. Long term exposure to beryllium can increase the risk of developing lung cancer. The more common and serious health hazard from beryllium today is chronic beryllium disease (CBD), discussed below. It continues to occur in industries as diverse as metal recycling, dental laboratories, alloy manufacturing, nuclear weapons production, defense industries, and metal machine shops that work with alloys containing small amounts of beryllium.

Chronic beryllium disease (CBD)

Some people (1-15%) become sensitive to beryllium. These individuals may develop an inflammatory reaction that principally targets the respiratory system and skin. This condition is called chronic beryllium disease (CBD), and can occur within a few months or many years after exposure to higher than normal levels of beryllium (greater than 0.02 $\mu g/m^3$). This disease causes fatigue, weakness, night sweats and can cause difficulty in breathing and a persistent dry cough. It can result in anorexia, weight loss, and may also lead to right-side heart enlargement and heart disease in advanced cases. Some people who are sensitized to beryllium may not have any symptoms. The disease is treatable but not curable. CBD occurs when the body's immune system recognizes beryllium particles as foreign material and mounts an immune system attack against the particles. Because these particles are typically inhaled into the lungs, the lungs becomes the major site where the immune system responds. The lungs become inflamed, filled with large numbers of white blood cells that accumulate wherever beryllium particles are found. The cells form balls around the beryllium particles called "granulomas." When enough of these granulomas develop, they interfere with the normal function of the organ. Over time, the lungs become stiff and lose their ability to help transfer oxygen from the air into the bloodstream. Patients with CBD develop difficulty inhaling and exhaling sufficient amounts of air and the amount of oxygen in their bloodstreams falls. Treatment of such patients includes use of oxygen and medicines that try to suppress the immune system's over-reaction to beryllium. A class of immunosuppressive medicines called glucocorticoids (example: prednisone), is most commonly used as treatment. The general population is unlikely to develop acute or chronic beryllium disease because ambient air levels of beryllium are normally very low (0.00003-0.0002 $\mu g/m^3$).

Ingestion

Swallowing beryllium has not been reported to cause effects in humans because very little beryllium is absorbed from the stomach and intestines. Ulcers have been seen in dogs ingesting beryllium in the diet. Beryllium contact with skin that has been scraped or cut may cause rashes or ulcers, or bumps under the skin called "granulomas."

The United States Department of Health and Human Services (DHHS) and the International Agency for Research on Cancer (IARC) have determined that beryllium is a human carcinogen. The U.S. Environmental Protection Agency (EPA) has determined that beryllium is a probable human carcinogen. The EPA has estimated that lifetime exposure to 0.04 $\mu g/m^3$ beryllium can result in a one in a thousand chance of developing cancer.

Effects on children

There are no studies on the health effects of children exposed to beryllium, although individual cases of CBD have been reported in children of beryllium workers from the 1940s. It is likely that the health effects seen in children exposed to beryllium will be similar to the effects seen in adults. It is unknown whether children differ from adults in their susceptibility to beryllium. It is unclear whether beryllium is teratogenic.

Detection in the body

Beryllium can be measured in the urine and blood. The amount of beryllium in blood or urine may not indicate time or quantity of exposure. Beryllium levels can also be measured in lung and skin samples. While such measurements may help establish that exposure has occurred, other tests are used to determine if that exposure has resulted in health effects. A blood test, the blood beryllium lymphocyte proliferation test (BeLPT), identifies beryllium sensitization and has predictive value for CBD. The BeLPT has become the standard test for detecting beryllium sensitization and CBD in individuals who are suspected of having CBD and to help distinguish it from similar conditions such as sarcoidosis. It is also the main test used in industry health programs to monitor whether disease is occurring among current and former workers who have been exposed to beryllium on the job. The test can detect disease that is at an early stage, or can detect disease at more advanced stages of illness as well. The BeLPT can also be performed using cells obtained from a person's lung by a procedure called "bronchoscopy."

Industrial release limits

Typical levels of beryllium that industries may release into the air are of the order of 0.01 $\mu g/m^3$, averaged over a 30-day period, or 2 $\mu g/m^3$ of workroom air for an 8-hour work shift. Compliance with the current U.S. Occupational Safety and Health Administration (OSHA) permissible exposure limit for beryllium of 2 $\mu g/m^3$ has been determined to be inadequate to protect workers from developing beryllium sensitization and CBD. The American Conference of Governmental Industrial Hygienists (ACGIH), which is an independent organization of experts in the field of occupational health, has proposed a threshold limit value (TLV) of 0.05 $\mu g/m^3$ in a 2006 Notice of Intended Change (NIC). This TLV is 40 times lower than the current OHSA permissible exposure limit, reflecting the ACGIH analysis of best available peer-reviewed research data concerning how little airborne beryllium is required to cause sensitization and CBD. Because it can be difficult to control industrial exposures to beryllium, it is advisable to use any methods possible to reduce airborne and surface contamination by beryllium, to minimize the use of beryllium and beryllium-containing alloys whenever possible, and to educate people about the potential hazards if they are likely to encounter beryllium dust or fumes.

See also

- Beryllium compounds

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External links

- Computational Chemistry Wiki (http://www.compchemwiki.org/index.php?title=Beryllium)
- It's Elemental – Beryllium (http://education.jlab.org/itselemental/ele004.html)
- National Pollutant Inventory - Beryllium and compounds (http://www.npi.gov.au/database/substance-info/profiles/13.html)
- WebElements.com – Beryllium (http://www.webelements.com/webelements/elements/text/Be/index.html)

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